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IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In re Application of: Ji U. Lee et al.	§ §	
Serial No.: 10/671,143	§ § §	Group Art Unit: 1753 Examiner: Rodney G. McDonald
Filed: September 25, 2003	§ §	
For: SELF-ALIGNED GATED CARBON NANOTUBE FIELD EMITTER STRUCTURES AND ASSOCIATED METHODS OF FABRICATION	§ § § §	Atty. Docket: 125695-1/YOD GERD:0255

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July 5, 2007	Lynda Howell
Date	Lynda Howell

APPEAL BRIEF PURSUANT TO 37 C.F.R. §§ 41.31 AND 41.37 AND REPLY TO THE NOTICE OF NON-COMPLIANT APPEAL BRIEF

This Appeal Brief is being filed in furtherance to the Notice of Appeal mailed on September 25, 2006, and received by the Patent Office on September 25, 2006. This is also in Reply to the Notice of Non-Compliant Appeal brief mailed on June 5, 2007.

1. **REAL PARTY IN INTEREST**

The real party in interest is General Electric Company, the Assignee of the above-referenced application by virtue of the Assignment to General Electric Company by William Huber and Ji-Ung Lee, recorded at reel 014655, frame 0497, and dated May 17, 2004. Accordingly, General Electric Company will be directly affected by the Board's decision in the pending appeal.

2. **RELATED APPEALS AND INTERFERENCES**

Appellants are unaware of any other appeals or interferences related to this Appeal. The undersigned is Appellants' legal representative in this Appeal.

3. **STATUS OF CLAIMS**

Claims 1-57 and 99 are currently pending, are currently under final rejection and, thus, are the subject of this Appeal. Claims 58-98 were earlier canceled.

4. **STATUS OF AMENDMENTS**

As the instant claims have not been amended at any time, there are no outstanding amendments to be considered by the Board.

5. **SUMMARY OF CLAIMED SUBJECT MATTER**

The present invention relates generally to the field of nanotechnology. *See,* Application page 1, paragraph 1. More particularly, the present invention relates to the self-aligned gated carbon nanotube field emitter structures and associated methods of fabrication.

The carbon nanotubes are typically configured in a triode field emitter structure, including a plurality of carbon nanotubes disposed within a plurality of micro-cavities that are arranged in an array, a common anode or gate electrode for modulating an emission (tunneling) current, a common dielectric layer and a common cathode electrode. *See,* Application page 1, paragraph 2, lines 4-8. Triode field emitter structures have

typically been fabricated using the Spindt process, which utilizes a metal, such as molybdenum (Mo), or a semiconductor material, such as silicon (Si), to form a plurality of regularly-spaced micro-tips. *See,* Application, page 1, paragraph 3, lines 1-3. The emitted electrons are accelerated towards the gate electrode, to which a voltage of, for example, a few to several hundred volts is applied. As a result of the relatively high gate voltage applied, residual gas particles in the surrounding vacuum collide with the emitted electrons and are ionized. The ions bombard the micro-tips, potentially damaging them. Likewise, the micro-tips are subject to pollution and deterioration, degrading the performance of the FEA and limiting its operating life. Because of these problems, the use of carbon nanotubes, which have a relatively high chemical stability, a relatively high aspect ratio and relatively high current carrying capability, is preferred as a collective electron emission source. *See* Application, pages 1-2, paragraph 3, lines 6-14. Conventional carbon nanotube FEAs fabricated using a modified Spindt-like process, however, suffer from several problems. The first problem is that each micro-cavity contains a tangled mass of carbon nanotubes. *See* Application, page 2, paragraph 5, lines 1-3. The second problem is that the carbon nanotubes are generally, but not universally, aligned perpendicular to the associated gate. *See* Application, page 2, paragraph 5, lines 7-8.

The above discussed and other drawbacks and deficiencies of the prior art are overcome or alleviated by the fabrication method of the claimed invention. The Application contains three independent claims, namely, claims 1, 32 and 99, all of which are the subject of this Appeal. The subject matter of these claims is summarized below.

With regard to the aspect of the invention set forth in independent claim 1, discussions of the recited features of claim 1 can be found at least in the below cited locations of the specification and drawings. By way of example, an embodiment in accordance with the present invention relates to a method of fabricating a self-aligned gated carbon nanotube field emitter structure including providing a substrate (*e.g.*, 50). *See, e.g., id.* at page 3, paragraph 21, lines 1-3; see also, FIG. 3. The method further

comprises depositing a dielectric material (*e.g.*, 52) on the surface of the substrate. *See, e.g., id.* at page 8, paragraph 21, lines 10-12; see also, FIG. 3. Next, a conductor layer (*e.g.*, 54) is deposited on the surface of the dielectric material (*e.g.*, 52). *See, e.g., id.* at page 9, paragraph 21, lines 19-24; *see also,* FIG. 3. Further, the conductor layer (*e.g.*, 54) is selectively etched to form an opening in the conductor layer (*e.g.*, 54). *See, e.g., id.* at page 9, paragraph 22; *see also,* FIG. 4. The dielectric material is selectively etched to form a micro-cavity (*e.g.*, 56) in the dielectric material (*e.g.*, 52). *See, e.g., id.* at page 9, paragraph 22; *see also,* FIG. 4. Subsequently, a base layer (*e.g.*, 60) structure is deposited in the micro-cavity (*e.g.*, 56) adjacent to the surface of the substrate (*e.g.*, 50). The base layer (*e.g.*, 60) structure has a substantially conical shape. *See, e.g., id.* at page 9, paragraph 23; *see also,* FIG. 5. A catalyst (*e.g.*, 62) is then deposited on a portion of the surface of the base layer (*e.g.*, 60) structure, wherein the catalyst (*e.g.*, 62) is suitable for growing at least one carbon nanotube. *See, e.g., id.* at page 9, paragraph 24; *see also,* FIG. 5. Further, an electrical potential is applied to the substrate (*e.g.*, 50) and the conductor layer (*e.g.*, 52), wherein the electrical potential generates a plurality of electrical field lines that are deflected around the surface of the base layer (*e.g.*, 60) structure, and wherein the plurality of electrical field lines have a strength that is greatest in a direction substantially perpendicular to the surface of the substrate (*e.g.*, 50). *See, e.g., id.* at page 11, paragraph 25; *see also,* FIG. 6. Lastly, at least one carbon nanotube is grown from the catalyst in the presence of the plurality of electrical field lines (*e.g.*, 72) in a direction substantially perpendicular to the surface of the substrate (*e.g.*, 50). *See, e.g., id.* at page 12, paragraph 26; *see also*, FIG. 6.

With regard to the aspect of the invention set forth in independent claim 32, discussions of the recited features of claim 32 can be found at least in the below cited locations of the specification and drawings. By way of example, an embodiment in accordance with the present invention relates to a method of fabricating a triode carbon nanotube field emitter structure including providing a cathode electrode (*e.g.*, 50). *See, e.g., id.* at page 3, paragraph 21, lines 1-3; *see also*, FIG. 3. The method further comprises depositing a dielectric material (*e.g.*, 52) on the surface of the cathode

electrode (*e.g.*, 50). *See, e.g., id.* at page 8, paragraph 21, lines 10-12; *see also*, FIG. 3. Next, a gate electrode (*e.g.*, 54) is deposited on the surface of the dielectric material (*e.g.*, 52). *See, e.g., id.* at page 9, paragraph 21, lines 19-24; *see also,* FIG. 3. Further, the gate electrode (*e.g.*, 54) is selectively etched to form an opening in the gate electrode (*e.g.*, 54). *See, e.g., id.* at page 9, paragraph 22; *see also,* FIG. 4. The dielectric material (*e.g.*, 52) is selectively etched to form a micro-cavity in the dielectric material (*e.g.*, 52). *See, e.g., id.* at page 9, paragraph 22; *see also,* FIG. 4. Subsequently, a conductive base layer structure (*e.g.*, 60) is deposited in the micro-cavity adjacent to the surface of the cathode electrode (*e.g.*, 50). The conductive base layer structure (*e.g.*, 60) has a substantially conical shape. *See, e.g., id.* at page 9, paragraph 23; *see also,* FIG. 5. A catalyst (*e.g.*, 62) is then deposited on a portion of the surface of the conductive base layer structure (*e.g.*, 60), the catalyst (*e.g.*, 62) being suitable fór growing at least one carbon nanotube. *See, e.g., id.* at page 9, paragraph 24; *see also,* FIG. 5. Further, an electrical potential is applied to the cathode electrode (*e.g.*, 50) and the gate electrode (*e.g.*, 54), wherein the electrical potential generates a plurality of electrical field lines that are deflected around the surface of the conductive base layer structure (*e.g.*, 60), and wherein the plurality of electrical field lines have a strength that is greatest in a direction substantially perpendicular to the surface of the cathode electrode (*e.g.*, 50). *See, e.g., id.* at page 11, paragraph 25; *see also,* FIG. 6. Lastly, at least one carbon nanotube is grown from the catalyst (*e.g.*, 62) in the presence of the plurality of electrical field lines, in a direction substantially perpendicular to the surface of the cathode electrode (*e.g.*, 50). *See, e.g.,* id. at page 12, paragraph 26; *see also*, FIG. 6.

With regard to the aspect of the invention set forth in independent claim 99, discussions of the recited features of claim 99 can be found at least in the below cited locations of the specification and drawings. By way of example, an embodiment in accordance with the present invention relates to a method of fabricating a self-aligned gated carbon nanotube field emitter structure including providing a substrate (*e.g.*, 50). *See, e.g., id.* at page 3, paragraph 21, lines 1-3; see also, FIG. 3. The method further comprises depositing a dielectric material (*e.g.*, 52) on the surface of the substrate. *See,*

e.g.; *id.* at page 8, paragraph 21, lines 10-12; see also, FIG. 3. Next, a conductor layer (*e.g.*, 54) is deposited on the surface of the dielectric material (*e.g.*, 52). *See, e.g., id.* at page 9, paragraph 21, lines 19-24; *see also,* FIG. 3. Further, the conductor layer (*e.g.*, 54) is selectively etched to form an opening in the conductor layer (*e.g.*, 54). *See, e.g., id.* at page 9, paragraph 22; *see also,* FIG. 4. The dielectric material is selectively etched to form a micro-cavity (*e.g.*, 56) in the dielectric material (*e.g.*, 52). *See, e.g., id.* at page 9, paragraph 22; *see also,* FIG. 4. Subsequently, a base layer (*e.g.*, 60) structure is deposited in the micro-cavity (*e.g.*, 56) adjacent to the surface of the substrate (*e.g.*, 50). *See, e.g., id.* at page 9, paragraph 23; *see also,* FIG. 5. A catalyst (*e.g.*, 62) is then deposited on a portion of the surface of the base layer (*e.g.*, 60) structure, the catalyst (*e.g.*, 62) being suitable for growing at least one carbon nanotube. *See, e.g., id.* at page 9, paragraph 24; *see also,* FIG. 5. Further, an electrical potential is applied to the substrate (*e.g.*, 50) and the conductor layer (*e.g.*, 52), wherein the electrical potential generates a plurality of electrical field lines that are deflected around the surface of the base layer (*e.g.*, 60) structure, and wherein the plurality of electrical field lines have a strength that is greatest in a direction substantially perpendicular to the surface of the substrate (*e.g.*, 50). *See, e.g., id.* at page 11, paragraph 25; *see also,* FIG. 6. Lastly, at least one carbon nanotube is grown from the catalyst in the presence of the plurality of electrical field lines (*e.g.*, 72) in a direction substantially perpendicular to the surface of the substrate (*e.g.*, 50). *See*, *e.g.*, *id.* at page 12, paragraph 26; *see also*, FIG. 6.

6. GROUNDS OF REJECTION TO BE REVIEWED ON APPEAL

First Ground of Rejection for Review on Appeal:

Appellants respectfully urge the Board to review and reverse the Examiner's first ground of rejection in which the Examiner rejected claims 1-6, 9, 13-19, 22-27, 29, 31-38, 42-48, 51, 52, 54-56 and 99 under 35 U.S.C. §103(a) as being unpatentable over U.S. Patent No. 6,339,281 (hereinafter "Lee") in view of the U.S. Patent Application Publication No. 2004/0067602 (hereinafter "Jin").

Second Ground of Rejection for Review on Appeal:

Appellants respectfully urge the Board to review and reverse the Examiner's second ground of rejection in which the Examiner rejected claims 7, 10-12 and 39-41 under 35 U.S.C. §103(a) as being unpatentable over Lee in view of Jin as applied to claims 1-6, 9, 13-19, 22-27, 29, 31-38, 42-48, 51, 52, 54-56 and 99, and further in view of U.S. Patent No. RE38,561 (hereinafter "RE38,561").

Third Ground of Rejection for Review on Appeal:

Appellants respectfully urge the Board to review and reverse the Examiner's third ground of rejection in which the Examiner rejected claim 8 under 35 U.S.C. §103(a) as being unpatentable over Lee in view of Jin as applied to claims 1-6, 9, 13-19, 22-27, 29, 31-38, 42-48, 51, 52, 54-56 and 99, and further in view of U.S. Patent No. 5,620,350 (hereinafter "Takemura").

Fourth Ground of Rejection for Review on Appeal:

Appellants respectfully urge the Board to review and reverse the Examiner's fourth ground of rejection in which the Examiner rejected claims 20, 21, 49 and 50 under 35 U.S.C. §103(a) as being unpatentable over Lee in view of Jin as applied to claims 1-6, 9, 13-19, 22-27, 29, 31-38, 42-48, 51, 52, 54-56 and 99, and further in view of Applied, Physics Letters, Volume 79, Number 19, November 5, 2001, page 3155-3157, "Electric field directed growth of aligned single walled carbon nanotubes" (hereinafter "Zhang").

Fifth Ground of Rejection for Review on Appeal:

Appellants respectfully urge the Board to review and reverse the Examiner's fifth ground of rejection in which the Examiner rejected claims 28 and 57 under 35 U.S.C. §103(a) as being unpatentable over Lee in view of Jin as applied to claims 1-6, 9, 13-19, 22-27, 29, 31-38, 42-48, 51, 52, 54-56 and 99, and further in view of Applied, Physics Letters, Volume 77, Number 16, August 2000, page 830-832, "Plasma-induced alignment of carbon nanotubes" (hereinafter "Bower").

Sixth Ground of Rejection for Review on Appeal:

Appellants respectfully urge the Board to review and reverse the Examiner's sixth ground of rejection in which the Examiner rejected claims 30 and 53 under 35 U.S.C. § 103(a) as being unpatentable over Lee in view of Jin as applied to claims 1-6, 9, 13-19, 22-27, 29, 31-38, 42-48, 51, 52, 54-56 and 99, and further in view of Huang (U.S. Pat. 5,451,830) and Chen (U.S. Pat. 6,815,877).

7. ARGUMENT

As discussed in detail below, the Examiner has improperly rejected the pending claims. Further, the Examiner has misapplied long-standing and binding legal precedents and principles in rejecting the claims under Section 103. Accordingly, Appellants respectfully request full and favorable consideration by the Board, as Appellants strongly believe that claims 1-57 and 99 are in condition for allowance.

A. Ground of Rejection No. 1:

The Examiner rejected claims 1-6, 9, 13-19, 22-27, 29, 31-38, 42-48, 51, 52 and 54-57 under 35 U.S.C. §103(a) as being unpatentable over Lee in view of Jin.

1. Legal basis required to establish a *prima facie* case of obviousness.

The burden of establishing a *prima facie* case of obviousness falls on the Examiner. *Ex parte Wolters and Kuypers*, 214 U.S.P.Q. 735 (B.P.A.I. 1979). Obviousness cannot be established by combining the teachings of the prior art to produce the claimed invention absent some teaching or suggestion supporting the combination. *ACS Hospital Systems, Inc. v. Montefiore Hospital*, 732 F.2d 1572, 1577, 221 U.S.P.Q. 929, 933 (Fed. Cir. 1984). Accordingly, to establish a *prima facie* case, the Examiner must not only show that the combination includes all of the claimed elements, but also a convincing line of reason as to why one of ordinary skill in the art would have found the claimed invention to have been obvious in light of the teachings of the references. *Ex parte Clapp*, 227 U.S.P.Q. 972 (B.P.A.I. 1985). When prior art references require a selected combination to render obvious a subsequent invention, there must be some

reason for the combination other than the hindsight gained from the invention itself, i.e., something in the prior art as a whole must suggest the desirability, and thus the obviousness, of making the combination. *Uniroyal Inc. v. Rudkin-Wiley Corp.*, 837 F.2d 1044, 5 U.S.P.Q.2d 1434 (Fed. Cir. 1988).

2. <u>The Examiner's rejection of independent claim 1, 32 and 99 is improper because the rejection fails to establish a *prima facie* case of obviousness.</u>

Independent claim 1 recites:

> A method for fabricating a self-aligned gated carbon nanotube field emitter structure, comprising the steps of:
>
> providing a substrate, wherein the substrate has a surface;
>
> depositing a dielectric material on the surface of the substrate, wherein the dielectric material has a surface;
>
> depositing a conductor layer on the surface of the dielectric material, wherein the conductor layer has a surface;
>
> selectively etching the conductor layer to form an opening in the conductor layer;
>
> selectively etching the dielectric material to form a micro-cavity in the dielectric material;
>
> depositing a base layer structure in the micro-cavity adjacent to the surface of the substrate, wherein the base layer structure has a surface, and wherein the base layer structure has a substantially conical shape;
>
> depositing a catalyst on a portion of the surface of the base layer structure, wherein the catalyst is suitable for growing at least one carbon nanotube;
>
> *applying an electrical potential to the substrate and the conductor layer*, wherein the electrical potential generates a plurality of electrical field lines that are deflected around the surface of the base layer structure, and wherein the plurality of electrical field lines have a strength that is greatest in a direction substantially perpendicular to the surface of the substrate; and

growing at least one carbon nanotube from the catalyst in the presence of the plurality of electrical field lines, wherein the at least one carbon nanotube is grown in a direction substantially perpendicular to the surface of the substrate. (Emphasis added.)

Independent Claim 32 recites:

A method for fabricating a triode carbon nanotube field emitter structure, comprising the steps of:

providing a cathode electrode, wherein the cathode electrode has a surface;

depositing a dielectric layer on the surface of the cathode electrode, wherein the dielectric layer has a surface;

depositing a gate electrode on the surface of the dielectric layer, wherein the gate electrode has a surface;

selectively etching the gate electrode to form an opening in the gate electrode;

selectively etching the dielectric layer to form a micro-cavity in the dielectric layer;

depositing a conductive base layer structure in the micro-cavity adjacent to the surface of the cathode electrode, wherein the conductive base layer structure has a surface, and wherein the conductive base layer structure has a substantially conical shape;

depositing a catalyst on a portion of the surface of the conductive base layer structure, wherein the catalyst is suitable for growing at least one carbon nanotube;

applying an electrical potential to the cathode electrode and the gate electrode, wherein the electrical potential generates a plurality of electrical field lines that are deflected around the surface of the conductive base layer structure, and wherein the plurality of electrical field lines have a strength that is greatest in a direction substantially perpendicular to the surface of the cathode electrode; and

growing at least one carbon nanotube from the catalyst in the presence of the plurality of electrical field lines, wherein the at least one carbon nanotube is grown in a direction substantially perpendicular to the surface of the cathode electrode. (Emphasis added.)

Independent Claim 99 recites:

> A method for fabricating a self-aligned gated carbon nanotube field emitter structure, comprising the steps of:
>
> providing a substrate, wherein the substrate has a surface;
>
> depositing a dielectric material on the surface of the substrate, wherein the dielectric material has a surface;
>
> depositing a conductor layer on the surface of the dielectric material, wherein the conductor layer has a surface;
>
> selectively etching the conductor layer to form an opening in the conductor layer;
>
> selectively etching the dielectric material to form a micro-cavity in the dielectric material;
>
> depositing a base layer structure in the micro-cavity adjacent to the surface of the substrate, wherein the base layer structure has a surface;
>
> depositing a catalyst on a portion of the surface of the base layer structure, wherein the catalyst is suitable for growing at least one carbon nanotube;
>
> *applying an electrical potential to the substrate and the conductor layer*, wherein the electrical potential generates a plurality of electrical field lines that are deflected around the surface of the base layer structure, and wherein the plurality of electrical field lines have a strength that is greatest in a direction substantially perpendicular to the surface of the substrate; and
>
> growing at least one carbon nanotube from the catalyst in the presence of the plurality of electrical field lines, wherein the at least one carbon nanotube is grown in a direction substantially perpendicular to the surface of the substrate. (Emphasis added.)

a. **Even a combination of Lee and Jin fails to disclose the creation of an *in-situ* electrical field in the substrate.**

In rejecting independent claim 1, The Examiner stated that Lee teaches a method of fabricating a triode carbon nanotube field emitter array. The Examiner relied upon the Abstract section of Lee to support his arguments. The cited passage reads:

> A method for fabricating a triode field emitter array using carbon nanotubes having excellent electron emission characteristics is provided. In the method for fabricating a triode-structure carbon nanotube field emitter array, a catalyst layer is formed on a cathode electrode without forming a base layer, and carbon nanotubes are grown on the catalyst layer using a Spind't process. In this method, a non-reactive layer is formed on a catalyst layer outside the micro-cavity such that the carbon nanotubes can be grown only on the catalyst within the micro-cavity. Accordingly, even through a separation layer is etched and removed, since carbon nanotubes do not exist outside the micro-cavity, it does not happen that carbon nanotubes are drifted into the micro-cavities. Therefore, the fabrication yield is increased, and the fabrication cost is decreased.

Further, the Examiner relied upon Jin to teach applying an electrical potential to cause a field to form at the substrate such that the carbon nanotubes grow in a direction perpendicular to the surface of the substrate. The Examiner cited passages at paragraphs 50 and 14 from Jin in support of the arguments. The passages cited at paragraph 50 reads:

> The fifth step is to grow the nanowires from each nano island catalyst position. Advantageously the growth is effected by the chemical vapor deposition (CVD) process. *The vertical alignment of the nanowire during growth can be enhanced by an electrical field globally applied along the vertical direction (perpendicular to the substrate) or by an intrinsically present electric field, as is used in microwave plasma CVD growth* (see Bower et al.). FIG. 2(d) shows the gate structure with individual nanowires 26 vertically grown from nano islands near the center of the gated emission apertures 25. (Emphasis added.)

Applicants have closely considered the cited passage and, indeed, the Jin patent as a whole. The cited passage from Jin, and the entire reference, do not support the Examiner's position, however. The passage cited by the Examiner from Jin at paragraph 50, teaches applying an electric field *globally or intrinsically.* The cited passage does not

teach or even suggest using the substrate and the conductor layer to apply the electrical potential to the arrangement during the growth of the nanowires.

Therefore, the combination of Lee and Jin would not teach applying an electric potential *in-situ*, that is, between a substrate and a conductor layer. Even if Lee and Jin could be combined, the combination would not logically teach a person skilled in the art to apply the electric potential to the substrate. On the contrary, the combination would more readily teach placing the *entire structure* of Lee in the CVD chamber of Jin, subjected to an external electric field, or to the electric field present inside the CVD chamber. The step of applying the electrical potential between the substrate and conductor layer is completely missing from the method of fabricating nanotubes as suggested by Jin. There is no motivation for, and the references do not teach, creating a field *within the device itself* by applying an electrical potential to its own layers.

b. <u>The Examiner has misinterpreted the claim language.</u>

The Board should note that the step of applying an electrical potential to the substrate and the conductor layer is not equivalent to *globally applying an electric field* to the chamber where the fabrication of the nanotube is taking place. The specification must be used to interpret the meaning of the claim terms. In the present case, it is exceedingly clear that although the electric field may exist between the nanotube in the claimed invention as well as in Jin. However, Jin fails to teach or even suggest using the substrate and the conductor layer to apply electrical potential.

c. <u>Dependent claims 2-31 and 33-57.</u>

The claims 2-31 and 33-57 are believed to be patentable as they depend directly or indirectly from allowable independent claims 1 and 32. Therefore, it is respectfully submitted that insomuch as independent claims 1and 32 are allowable, claims depending therefrom are allowable at least by virtue of their dependency from allowable base claims.

B. **Ground of Rejection No. 2:**

The Examiner rejected claims 5-6 and 22-23 as rejected under 35 U.S.C. §103(a) as being unpatentable over Lee in view of Jin, and further in view of RE38,561.

In response to rejection of claims depending from claim 1, it is respectfully submitted that the secondary references do not obviate the deficiencies of Lee and Jin discussed above. Accordingly, insomuch as independent claim 1 is allowable, claims depending therefrom are allowed at least by virtue of their dependency from an allowable base claim.

C. **Ground of Rejection No. 3:**

The Examiner rejected claim 8 under 35 U.S.C. §103(a) as being obvious over Lee in view of Jin, and further in view of Takemura.

Here again, in response to rejection of claims depending from claim 1, it is respectfully submitted that the secondary references do not obviate the deficiencies of Lee and Jin discussed above. Accordingly, insomuch as independent claim 1 is allowable, claim 8 depending therefrom is allowed at least by virtue of its dependency from an allowable base claim.

D. **Ground of Rejection No. 4:**

The Examiner rejected claims 20, 21, 49 and 50 under 35 U.S.C. §103(a) as being unpatentable over Lee in view of Jin, and further in view of Zhang.

As before, in response to rejection of claims depending from claims 1 and 32, it is respectfully submitted that the secondary references do not obviate the deficiencies of Lee and Jin discussed above. Accordingly, insomuch as independent claims 1 and 32 are allowable, claims depending therefrom are allowed at least by virtue of their dependency from allowable base claims.

E. **Ground of Rejection No. 5:**

The Examiner rejected claims 28 and 57 under 35 U.S.C. §103(a) as being unpatentable over Lee in view of Jin, and further in view of Bower.

In response to rejection of claims depending from claims 1 and 32, it is respectfully submitted that the secondary references do not obviate the deficiencies of Lee and Jin discussed above. Accordingly, insomuch as independent claims 1 and 32 are allowable, claims depending therefrom are allowed at least by virtue of their dependency from allowable base claims.

F. **Ground of Rejection No. 6:**

The Examiner rejected claims 30 and 53 under 35 U.S.C. § 103(a) as being unpatentable over Lee in view of Jin, and further in view of Huang and Chen.

In response to rejection of claims depending from claims 1 and 32, it is respectfully submitted that the secondary references do not obviate the deficiencies of Lee and Jin discussed above. Accordingly, insomuch as independent claims 1 and 32 are allowable, claims depending therefrom are allowed at least by virtue of their dependency from allowable base claims.

Conclusion

Appellants respectfully submit that all pending claims are in condition for allowance. However, if the Examiner or Board wishes to resolve any other issues by way of a telephone conference, the Examiner or Board is kindly invited to contact the undersigned attorney at the telephone number indicated below.

Respectfully submitted,

Date: 7/5/2007

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8. APPENDIX OF CLAIMS ON APPEAL

Listing of Claims:

1. A method for fabricating a self-aligned gated carbon nanotube field emitter structure, comprising the steps of:

providing a substrate, wherein the substrate has a surface;

depositing a dielectric material on the surface of the substrate, wherein the dielectric material has a surface;

depositing a conductor layer on the surface of the dielectric material, wherein the conductor layer has a surface;

selectively etching the conductor layer to form an opening in the conductor layer;

selectively etching the dielectric material to form a micro-cavity in the dielectric material;

depositing a base layer structure in the micro-cavity adjacent to the surface of the substrate, wherein the base layer structure has a surface, and wherein the base layer structure has a substantially conical shape;

depositing a catalyst on a portion of the surface of the base layer structure, wherein the catalyst is suitable for growing at least one carbon nanotube;

applying an electrical potential to the substrate and the conductor layer, wherein the electrical potential generates a plurality of electrical field lines that are deflected around the surface of the base layer structure, and wherein the plurality of electrical field lines have a strength that is greatest in a direction substantially perpendicular to the surface of the substrate; and

growing at least one carbon nanotube from the catalyst in the presence of the plurality of electrical field lines, wherein the at least one carbon nanotube is grown in a direction substantially perpendicular to the surface of the substrate.

2. The method of claim 1, wherein the substrate comprises at least one of a metal, a semiconductor material, a metal deposited on a glass and a semiconductor material deposited on a glass.

3. The method of claim 1, wherein the dielectric material comprises at least one of an oxide, a nitride and a combination thereof.

4. The method of claim 3, wherein the oxide comprises at least one of SiO_2, Al_2O_3 and a combination thereof.

5. The method of claim 3, wherein the nitride comprises SiNx, wherein 0.5=x=1.5.

6. The method of claim 1, wherein the conductor layer comprises at least one of a metal and a semiconductor material.

7. The method of claim 6, wherein the metal comprises at least one of Mo, Pt, Al, Ti and a combination thereof.

8. The method of claim 6, wherein the semiconductor material comprises at least one of doped amorphous silicon and doped poly-silicon.

9. The method of claim 1, further comprising depositing a sacrificial layer on a portion of the surface of the conductor layer, wherein the sacrificial layer has a surface.

10. The method of claim 9, wherein the sacrificial layer comprises at least one of a metal, a semiconductor, an evaporated dielectric and a photoresist.

11. The method of claim 9, wherein the sacrificial layer is deposited on a portion of the surface of the conductor layer at a predetermined angle.

12. The method of claim 11, wherein the sacrificial layer is deposited on a portion of the surface of the conductor layer while the substrate is rotating at a predetermined rotational speed.

13. The method of claim 9, further comprising depositing a base layer on the surface of the sacrificial layer and a portion of the surface of the substrate, wherein the base layer has a surface, and wherein the base layer deposited on the portion of the surface of the substrate forms the base layer structure.

14. The method of claim 13, wherein the base layer comprises at least one of a metal and doped silicon.

15. The method of claim 1, wherein the base layer structure comprises at least one of a metal and doped silicon.

16. The method of claim 13, further comprising depositing the catalyst on a portion of the surface of the base layer.

17. The method of claim 16, further comprising removing the sacrificial layer, the corresponding base layer deposited on the surface of the sacrificial layer and the corresponding catalyst deposited on the surface of the base layer.

18. The method of claim 1, wherein the catalyst comprises at least one transition metal.

19. The method of claim 18, wherein the at least one transition metal comprises at least one of Ni, Fe and Co.

20. The method of claim 1, wherein the electrical potential applied to the substrate and the conductor layer is between about 0.1 V and about 5 V.

21. The method of claim 1, wherein the electric potential induces an electric field of at least 103 V/cm on the substantially conical shape.

22. The method of claim 1, wherein the at least one carbon nanotube has a length of between about 50 nm and about 1,000 nm.

23. The method of claim 22, wherein the at least one carbon nanotube has a length of between about 100 nm and about 500 nm.

24. The method of claim 1, wherein the at least one carbon nanotube comprises at least one of a single-walled carbon nanotube, a double-walled carbon nanotube and a multi-walled carbon nanotube.

25. The method of claim 1, wherein the step of growing the at least one carbon nanotube comprises growing the at least one carbon nanotube by chemical vapor deposition.

26. The method of claim 25, wherein the step of growing the at least one carbon nanotube by chemical vapor deposition comprises growing the at least one carbon nanotube in a chemical vapor deposition tube coupled to a flowing carbon source.

27. The method of claim 26, wherein the flowing carbon source is one of a methane source, an acetylene source and a combination thereof.

28. The method of claim 25, wherein the step of growing the at least one carbon nanotube by chemical vapor deposition comprises growing the at least one carbon nanotube by chemical vapor deposition at a temperature of between about 700 degrees C and about 1,000 degrees C.

29. The method of claim 1, wherein the at least one carbon nanotube comprises at least one of a metallic-type carbon nanotube and a semiconducting-type carbon nanotube.

30. The method of claim 1, wherein each of the depositing steps comprises a deposition technique selected from the group consisting of sputtering, thermal evaporation, electron-beam evaporation, chemical vapor deposition, plasma-enhanced chemical vapor deposition, low-pressure chemical vapor deposition and thermal oxide growth.

31. The method of claim 1, wherein the self-aligned gated carbon nanotube field emitter structure comprises a triode carbon nanotube field emitter structure.

32. A method for fabricating a triode carbon nanotube field emitter structure, comprising the steps of:

providing a cathode electrode, wherein the cathode electrode has a surface;

depositing a dielectric layer on the surface of the cathode electrode, wherein the dielectric layer has a surface;

depositing a gate electrode on the surface of the dielectric layer, wherein the gate electrode has a surface;

selectively etching the gate electrode to form an opening in the gate electrode;

selectively etching the dielectric layer to form a micro-cavity in the dielectric layer;

depositing a conductive base layer structure in the micro-cavity adjacent to the surface of the cathode electrode, wherein the conductive base layer structure has a surface, and wherein the conductive base layer structure has a substantially conical shape;

depositing a catalyst on a portion of the surface of the conductive base layer structure, wherein the catalyst is suitable for growing at least one carbon nanotube;

applying an electrical potential to the cathode electrode and the gate electrode, wherein the electrical potential generates a plurality of electrical field lines that are deflected around the surface of the conductive base layer structure, and wherein the plurality of electrical field lines have a strength that is greatest in a direction substantially perpendicular to the surface of the cathode electrode; and

growing at least one carbon nanotube from the catalyst in the presence of the plurality of electrical field lines, wherein the at least one carbon nanotube is grown in a direction substantially perpendicular to the surface of the cathode electrode.

33. The method of claim 32, wherein the cathode electrode comprises at least one of a metal, a semiconductor material, a metal deposited on a glass and a semiconductor material deposited on a glass.

34. The method of claim 32, wherein the dielectric material comprises at least one of an oxide, a nitride and a combination thereof.

35. The method of claim 34, wherein the oxide comprises at least one of SiO_2, Al_2O_3 and a combination thereof.

36. The method of claim 34, wherein the nitride comprises SiNx, wherein $0.5=x=1.5$.

37. The method of claim 32, wherein the gate electrode comprises at least one of a metal and a semiconductor material.

38. The method of claim 32, further comprising depositing a sacrificial layer on a portion of the surface of the gate electrode, wherein the sacrificial layer has a surface.

39. The method of claim 38, wherein the sacrificial layer comprises at least one of a metal, a semiconductor, an evaporated dielectric and a photoresist.

40. The method of claim 38, wherein the sacrificial layer is deposited on a portion of the surface of the gate electrode at a predetermined angle.

41. The method of claim 40, wherein the sacrificial layer is deposited on a portion of the surface of the gate electrode while the cathode electrode is rotating at a predetermined rotational speed.

42. The method of claim 38, further comprising depositing a conductive base layer on the surface of the sacrificial layer and a portion of the surface of the cathode electrode, wherein the conductive base layer has a surface, and wherein the conductive base layer deposited on the portion of the surface of the cathode electrode forms the conductive base layer structure.

43. The method of claim 42, wherein the conductive base layer comprises at least one of a metal and doped silicon.

44. The method of claim 32, wherein the conductive base layer structure comprises at least one of a metal and doped silicon.

45. The method of claim 42, further comprising depositing the catalyst on a portion of the surface of the conductive base layer.

46. The method of claim 45, further comprising removing the sacrificial layer, the corresponding conductive base layer deposited on the surface of the sacrificial layer and the corresponding catalyst deposited on the surface of the conductive base layer.

47. The method of claim 32, wherein the catalyst comprises a material comprising at least one transition metal.

48. The method of claim 47, wherein the at least one transition metal comprises at least one of Ni, Fe and Co.

49. The method of claim 32, wherein the electrical potential applied to the cathode electrode and the gate electrode is between about 0.1 V and about 5 V.

50. The method of claim 32, wherein the electrical potential induces an electric field of at least 103 V/cm on the substantially conical shape.

51. The method of claim 32, wherein the at least one carbon nanotube has a length of between about 50 nm and about 1,000 nm.

52. The method of claim 51, wherein the at least one carbon nanotube has a length of between about 100 nm and about 500 nm.

53. The method of claim 32, wherein each of the depositing steps comprises a deposition technique selected from the group consisting of sputtering, thermal evaporation, electron-beam evaporation, chemical vapor deposition, plasma-enhanced chemical vapor deposition, low-pressure chemical vapor deposition and thermal oxide growth.

54. The method of claim 32, wherein the step of growing the at least one carbon nanotube comprises growing the at least one carbon nanotube by chemical vapor deposition.

55. The method of claim 54, wherein the step of growing the at least one carbon nanotube by chemical vapor deposition comprises growing the at least one carbon nanotube in a chemical vapor deposition tube coupled to a flowing carbon source.

56. The method of claim 55, wherein the flowing carbon source is one of a methane source, an acetylene source and a combination thereof.

57. The method of claim 54, wherein the step of growing the at least one carbon nanotube by chemical vapor deposition comprises growing the at least one carbon nanotube by chemical vapor deposition at a temperature of between about 700 degrees C and about 1,000 degrees C.

99. A method for fabricating a self-aligned gated carbon nanotube field emitter structure, comprising the steps of:

providing a substrate, wherein the substrate has a surface;

depositing a dielectric material on the surface of the substrate, wherein the dielectric material has a surface;

depositing a conductor layer on the surface of the dielectric material, wherein the conductor layer has a surface;

selectively etching the conductor layer to form an opening in the conductor layer;

selectively etching the dielectric material to form a micro-cavity in the dielectric material;

depositing a base layer structure in the micro-cavity adjacent to the surface of the substrate, wherein the base layer structure has a surface;

depositing a catalyst on a portion of the surface of the base layer structure, wherein the catalyst is suitable for growing at least one carbon nanotube;

applying an electrical potential to the substrate and the conductor layer, wherein the electrical potential generates a plurality of electrical field lines that are deflected around the surface of the base layer structure, and wherein the plurality of electrical field lines have a strength that is greatest in a direction substantially perpendicular to the surface of the substrate; and

growing at least one carbon nanotube from the catalyst in the presence of the plurality of electrical field lines, wherein the at least one carbon nanotube is grown in a direction substantially perpendicular to the surface of the substrate.

9. <u>EVIDENCE APPENDIX</u>

None.

10. RELATED PROCEEDINGS APPENDIX

None.